

Nationaal Lucht- en Ruimtevaartlaboratorium

National Aerospace Laboratory NLR



NLR-Memorandum AMSTR-NLR-PR-078-Issue ~~1.0~~ **2.0**
CO2 end cap and pinch leaktest Procedure

National Aerospace Laboratory (NLR)

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Summary

For the AMS experiment onboard the International Space Station a thermal control system, known as the Tracker Thermal Control System (TTCS) is being developed. The TTCS basically consists of a mechanically pumped two-phase loop, where heat is collected at two evaporators and rejected at two radiators. The loop contains carbon dioxide. Critical parts of the loop are protected against freezing, using thermostats and heaters.

The TTCS is filled by CO₂ via a fill tube. This fill tube has to be sealed after filling. To check the leak rate after the filling the amount of CO₂ leaking from the fill tube is being measured with a mass spectrometer.

This document describes the plan and procedure for the CO₂ leak rate measurement of the fill tube.



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(14 pages in total)



1 Introduction

2 Reference documents

| Ref | Author(s) | Title |
|-----|-----------|-------|
| 1 | | |
| 2 | | |

3 Items under test

The items under test comprises

4 Test objectives and criteria

4.1 Objective

Verify the end cap and pinch leak is lower than the requirement.

4.2 Procedure in main steps

1. Perform measurement on air CO₂ concentration (health check mass spectrometer RGA)
2. Perform zero measurement on gN₂ (off-set/nulling)
3. Perform background measurement of measurement set-up with glued plastic flanges
4. Perform background measurement of measurement set-up on plastic flanges with O-rings
5. Perform on-line measurement with O-rings

In case the measurement with O-rings is not successful the flanges will be glued to the inlet tube (and of course removed afterwards).

5 Test procedure sheets

| | | | |
|------|--|------------------------|---------------------------|
| | TTCS CO₂ leak test | company: NLR | date: 29/10/2009 |
| | Fill in by hand. | engineer: W.de Grawe | location: CERN |
| Step | Action | Monitoring | Comment |
| 1. | Record TTCS | T.I. description | Value Result Primary ✓ ✓ |
| 2. | Record model (EM / QM / FM) | Model | FM ✓ |
| 3. | Record RGA equipment used | Manufacturer, type s/n | ESS 200D ESC1003216 ✓ |
| 4. | Record pressure sensor used | Manufacturer, type s/n | Draack PMP4070 Ø4900256 ✓ |
| 5. | Record multimeter used | Manufacturer, type s/n | Fluke 109 Ø4900256 ✓ |
| 6. | Record ambient pressure with equipment mentioned above | Ambient pressure | 0,9626bar ✓ |
| 7. | Record ambient temperature | Temperature | 20,9 °C ✓ |
| 8. | Record relative humidity | Relative humidity | 51,2 % ✓ |

| | | | |
|------|--|-------------------------------|--|
| | TTCS CO₂ leak test | company: NLR | date: 29/10/2009 |
| | Fill in by hand. | engineer: W. de Grawe | location: CERN |
| Step | Action | Monitoring | Comment |
| 9. | REFERENCE MEASUREMENT ON TEST FILL TUBE (OFF-LINE) (PLASTIC FLANGE GLUED) | Value | Result |
| 10. | Set up the CO ₂ leak test set-up with a test fill tube. | | ✓ |
| 11. | Make a picture of the CO ₂ leak test set-up as reference. Store picture in V:\jvanes\Projects\AMS-Tracker\documents\Procedures\AMSTR-NLR-PR-078 CO ₂ leak detection procedure | | ✓ |
| 12. | Flush the accumulation volume and the intermediate volumes with gN ₂ for at least 15 minutes to reduce the CO ₂ concentration | Accumulation time | 15 minutes or more <i>Start: 19:07 END: 19:22</i> |
| 13. | Set zero correction off | Zero correction setting | Off |
| 14. | Perform a measurement on ambient air with the RGA (Mass spectrometer) | ppm | ✓ |
| 15. | Store the ambient air measurement | CO ₂ concentration | 400 ppm |
| 16. | Check the CO ₂ concentration of step 14 | Time | 17:23 |
| 17. | Close the accumulation volume with the 3-way valve and the accumulation outlet valve. Record time and start accumulation time | | ✓ <i>Accumulation Volume = 1,10 bar</i> |

| Step | Action | Monitoring | Value | Result | Comment |
|------|---|-------------------------------|-----------------------|---|------------------|
| | TTCS CO ₂ leak test | | | company: NLR engineer: <i>Julie Gravel</i> | date: 26/10/2009 |
| | Fill in by hand. | | | | location: CERN |
| 18. | Connect the RGA to the measurement set-up | | | | ✓ |
| 19. | Start measuring on a gN ₂ flow with the RGA (mass spectrometer) | | | | ✓ |
| 20. | Make pictures of the CO ₂ leak verification measurement set-up. Store pictures in: V:\jvanes\Tracker\documents\Procedures\.... | | | | ✓ |
| 21. | Wait 55 minutes from start of accumulation time | Accumulation time – 5 minutes | 55 minutes | $P_{Vaccu} = 1,1201 \text{ bar}$ | ✓ |
| 22. | Perform a zero measurement with the RGA | | | <i>file: zero meas step 22</i> | ✓ |
| 23. | Set CO ₂ Ion current in the zero file | Ion current | $1,38 \cdot 10^{-11}$ | | ✓ |
| 24. | Set zero correction on | Zero correction setting | On | | ✓ |
| 25. | Measure the pressure in the accumulation volume | Absolute pressure [mbar] | | Ambient pressure + 0.06 / - 0.00 mbar | ✓ |
| 26. | Wait for end of accumulation time | Accumulation time | 60 minutes | | ✓ |

| | | | | |
|--------------------------------------|---|-------------------------------|------------------|---|
| TTCS CO₂ leak test | | company: NLR | date: 29/10/2009 | |
| Step | Action | engineer: W.de Graw | location: CERN | |
| 27. | Perform the CO ₂ concentration measurement with the RGA | Monitoring | Value | Result |
| 28. | Store CO ₂ concentration measurement | CO ₂ concentration | About 20 ppm | 8.4 ppm @ Pamb. |
| 29. | Connect the RGA to a gN ₂ filled volume | Measurement | | file accumulation started too late, after actual measurement moment |
| 30. | Measure the accumulation volume of the test setup. | Accumulation volume [ml] | 108 mL | measured on 12/11/09 at NLR |
| 31. | Dry the test set-up. | | | ✓ |
| 32. | END OF REFERENCE MEASUREMENT OFF-LINE (PLASTIC FLANGE GLUED) | | | |
| 33. | REFERENCE MEASUREMENT ON TEST FILL TUBE (OFF-LINE) (PLASTIC FLANGE WITH O-RINGS) | | | |
| 34. | Set up the CO ₂ leak test set-up with a test fill tube. | | | ✓ |
| 35. | Put some vacuum grease on the O-rings and test fill tube | | | ✓ |
| 36. | Make a picture of the CO ₂ leak test set-up as reference. Store picture in V:\livanes\Projects\AMS-Tracker\documents\Procedures\AMSTR-NLR-PR-078 CO ₂ leak detection procedure | | | ✓ |

| Step | Action | Monitoring | Value | Result | Comment |
|------|--|-------------------------------|--------------------|------------------------|--|
| | TTCS CO ₂ leak test | | | company: NLR | date: 29/10/2009 |
| | Fill in by hand. | | | engineer: W. de Graeve | location: CERN |
| 37. | Flush the accumulation volume and the intermediate volumes with gN ₂ for at least 15 minutes to reduce the CO ₂ concentration | Accumulation time | 15 minutes or more | | Start: 19:36 |
| 38. | Set zero correction off | Zero correction setting | Off | | ✓ |
| 39. | Perform a measurement on ambient air with the RGA (Mass spectrometer) | | | | |
| 40. | Store the ambient air measurement | ppm | | | |
| 41. | Check the CO ₂ concentration of step 14 | CO ₂ concentration | 400 ppm | | |
| 42. | Close the accumulation volume with the 3-way valve and the accumulation outlet valve. Record time and start accumulation time | Time | | 19:52 | $P_{\text{Vaccum}} = 1,1905 \text{ bar}$ |
| 43. | Connect the RGA to the measurement set-up | | | | ✓ |
| 44. | Start measuring on a gN ₂ flow with the RGA (mass spectrometer) | | | | ✓ |
| 45. | Make pictures of the CO ₂ leak verification measurement set-up. Store pictures in: V:\jvanes\Tracker\documents\Procedures\.... | | | | ✓ |
| 46. | Wait 55 minutes from start of accumulation time | Accumulation time – 5 minutes | 55 minutes | | ✓ |

| | | | | |
|------|--|-------------------------------|---------------------------------------|--|
| | TTCS CO ₂ leak test | | company: NLR | date: 29/10/2009 |
| | Fill in by hand. | | engineer: W. de Grawe | location: CERN |
| Step | Action | Monitoring | Value | Result |
| 47. | Perform a zero measurement with the RGA | | | Comment <i>file: zero-meas-step47</i> |
| 48. | Set CO ₂ Ion current in the zero file | Ion current | | 1.16 · 10 ⁻¹¹ |
| 49. | Set zero correction on | Zero correction setting | On | / |
| 50. | Measure the pressure in the accumulation volume | Absolute pressure [mbar] | Ambient pressure + 0.06 / - 0.00 mbar | 1.1232 bar |
| 51. | Wait for end of accumulation time | Accumulation time | 60 minutes | / |
| 52. | Perform the CO ₂ concentration measurement with the RGA | CO ₂ concentration | About 20 ppm | Background level for CO ₂ leak test, time = 20:55 |
| 53. | Store CO ₂ concentration measurement | Measurement name | | <i>file: accu-step52</i> |
| 54. | Connect the RGA to a gN ₂ filled volume | | | / |
| 55. | Measure the accumulation volume of the test setup. | Accumulation volume [ml] | | |
| 56. | Dry the test set-up. | | | |

| Step | Action | Monitoring | Value | Result | Comment |
|------|--|----------------------------|-----------------------|---|--|
| 57. | END OF REFERENCE MEASUREMENT ON TEST FILL TUBE (OFF-LINE) (PLASTIC FLANGE WITH O-RINGS) | | | | |
| 58. | START ON-LINE MEASUREMENT | | | | |
| 59. | Position the plastic flange on the fill tube at 5 mm from the pinch pinch | Distance from pinch | 5 +/- 3 mm | | |
| 60. | Reduce the leakage between the fill tube and the plastic flange | | | With O-rings Pictures at times 19:00 22:53 | |
| 61. | Set up the CO ₂ leak test set-up on the fill tube. | | | | |
| 62. | Put some vacuum grease on the O-rings and fill tube | | | | |
| 63. | Flush the accumulation volume and the intermediate volume with gN ₂ for at least 15 minutes to reduce the CO ₂ concentration | Accumulation time | 15 minutes or more | start: 22:17 end: 22:32 | |
| 64. | Close the accumulation volume with the 3-way valve and the accumulation outlet valve. Record time and start accumulation time | Time | | 22:34 | $\rho_{\text{vacca}} = 1.1847 \text{ bar}$ |
| 65. | Connect the RGA to the measurement set-up | | | | |
| 66. | Set zero correction off | Zero correction setting | Off | | |
| 67. | Start measuring on a gN ₂ flow with the RGA | | | | |

| TTCS CO ₂ leak test | | company: NLR | date: 29/10/2009 |
|--------------------------------|---|-------------------------------|--|
| Step | Action | engineer: W.de Grawe | location: CERN |
| | | Monitoring | Comment |
| | | Value | Result |
| 68. | Make pictures of the CO ₂ leak measurement set-up. Store pictures in: V:\jvanes\AMS-Tracker\documents\Procedures\.... | | Timestamp pictures: 23:30 ✓ |
| 69. | Wait 55 minutes from start of accumulation time | Accumulation time – 5 minutes | ✓ |
| 70. | Perform a zero measurement with the RGA | | file: zero-meas-step70 ✓ |
| 71. | Set CO ₂ Ion current in the zero file | Ion current | 0.3 · 10 ⁻² A ✓ |
| 72. | Set zero correction on | Zero correction setting | On ✓ |
| 73. | Measure the pressure in the accumulation volume | Absolute pressure [mbar] | 4.1370 bar ✓ |
| 74. | Wait for end of accumulation time | Accumulation time | 60 minutes ✓ |
| 75. | Perform the CO ₂ concentration measurement with the RGA | CO ₂ concentration | 14,1 ppm Time: 23:35; P _{accu} @ 0,94 bar ✓ |
| 76. | Store CO ₂ concentration measurement name | Measurement name | file: accu-step73 ✓ |
| 77. | Perform a measurement on ambient air with the RGA. | CO ₂ concentration | 400 ppm 371 ppm ✓ |

| Step | Action | Monitoring | Value | Result | Comment |
|------|---|--|------------|---|------------------------------|
| | TTCS CO ₂ leak test | | | company: NLR | date: |
| | Fill in by hand. | | | engineer: | location: |
| 78. | Store the ambient air measurement | Measurement name | | | file : ambient.air.step 77 ✓ |
| 79. | Record ambient pressure with equipment mentioned above | Ambient pressure | 0,9643 bar | | ✓ |
| 80. | Record ambient temperature | Temperature | 20,7 °C | | ✓ |
| 81. | Check if the CO ₂ concentration of step 75 is lower than the allowed CO ₂ concentration. | CO ₂ concentration of step 75 | 19,5 ppm | 10,8 × 0,9643 / 2 | ✓ |
| | The allowed CO ₂ concentration = measured accumulation volume of step 30 in ml * average ambient pressure of step 6 and 79 * | Measured CO ₂ concentration step 75 | 14,1 ppm | $\frac{8,4 + 30}{2,55 \times 1,03} -$ | |
| | (measured CO ₂ concentration of step 27 plus 30 ppm)/(255 ml * 1.03 mbar) | | | $\left(\frac{30 \text{ ppm}}{255 \text{ ml} \times 1,03} + \frac{8,4 \text{ ppm}}{108 \text{ ml} \times 0,9643 \text{ bars}} \right) \times 108 \text{ ml} \times 0,94 \text{ bars}$ | |
| 82. | Remove plastic flanges and O-rings from fill tube | | | | ✓ |
| 83. | Clean inlet tube with IPA/remove vacuum grease | | | | ✓ |
| 84. | End of procedure | | | | ✓ |

Allowed CO₂ concentration = Normalized CO₂ measurement
 with calibrated leak + Normalized reference measurement:

$$\left(\frac{30 \text{ ppm}}{255 \text{ ml} \times 1,03 \text{ bars}} + \frac{CO_2 \text{ concentration step 27}}{Volume step 30 \times Pressure step 27} \right) \times Volume step 30 \times Pressure step 75$$

